

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
15 September 2005 (15.09.2005)

PCT

(10) International Publication Number
WO 2005/084225 A3

(51) International Patent Classification:
C30B 15/10 (2006.01) *C30B 29/06* (2006.01)

(74) Agent: **HETHERINGTON, Michael**; Mr. Michael Hetherington, P. O. Box 61047, Palo Alto, CA 94306 (US).

(21) International Application Number:
PCT/US2005/006058

(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(22) International Filing Date:
25 February 2005 (25.02.2005)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
10/789,638 27 February 2004 (27.02.2004) US

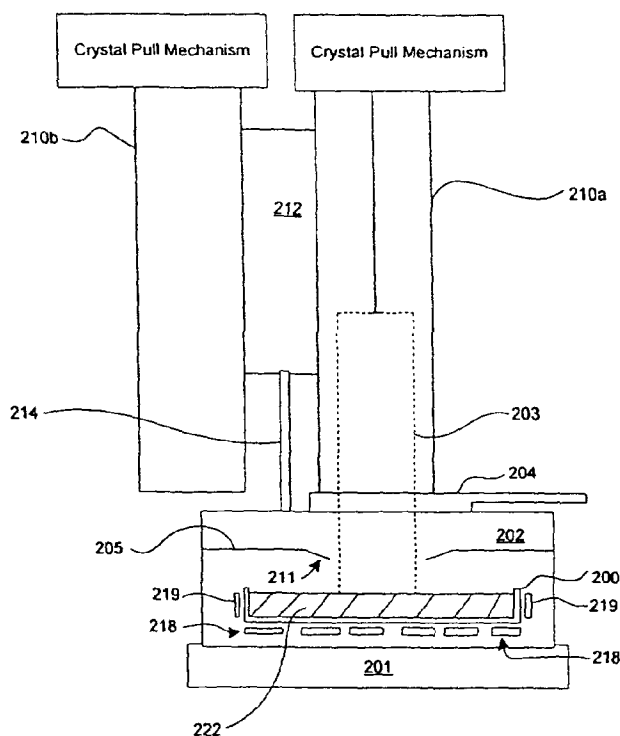
(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

(71) Applicant (*for all designated States except US*): **SO-LAICX, INC.** [US/US]; Solaicx, Inc., 5102 Calle del Sol, Santa Clara, CA 95054, CA 95054 (US).

(72) Inventor: **BENDER, David, L.**; 2212 Rustic Park Court, Thousand Oaks, CA 91362 (US).

[Continued on next page]

(54) Title: SYSTEM FOR CONTINUOUS GROWING OF MONOCRYSTALLINE SILICON



(57) Abstract: An improved system based on the Czochralski process for continuous growth of a single crystal ingot comprises a low aspect ratio, large diameter, and substantially flat crucible, including an optional weir surrounding the crystal. The low aspect ratio crucible substantially eliminates convection currents and reduces oxygen content in a finished single crystal silicon ingot. A separate level controlled silicon pre-melting chamber provides a continuous source of molten silicon to the growth crucible advantageously eliminating the need for vertical travel and a crucible raising system during the crystal pulling process. A plurality of heaters beneath the crucible establish corresponding thermal zones across the melt. Thermal output of the heaters is individually controlled for providing an optimal thermal distribution across the melt and at the crystal / melt interface for improved crystal growth. Multiple crystal pulling chambers are provided for continuous processing and high throughput.

WO 2005/084225 A3

**Declaration under Rule 4.17:**

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

(88) Date of publication of the international search report:

18 May 2007

Published:

— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

A. CLASSIFICATION OF SUBJECT MATTER
INV. C30B15/10 C30B29/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C30B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the International search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 659 421 A (JEWETT DAVID N [US]) 21 April 1987 (1987-04-21) the whole document -----	1-31
X	WO 86/06109 A (ENERGY MATERIALS CORP [US]) 23 October 1986 (1986-10-23) the whole document -----	1-31
A	WO 03/038161 A (MIDWEST RESEARCH INST [US]; WANG TIHU [US]; CISZEK THEODORE F [US]) 8 May 2003 (2003-05-08) the whole document -----	1,6,11, 15,17, 23,24, 27,29,31
A	DE 26 34 256 A1 (GNI I PI PEDKOMETALLITSCHESKOJ) 2 February 1978 (1978-02-02) ----- -/--	

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents:

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the international filing date
- *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

T later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

X document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

Y document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

* & * document member of the same patent family

Date of the actual completion of the international search

9 February 2007

Date of mailing of the international search report

21/02/2007

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Cook, Steven

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 410 494 A (FIEGL GEORGE [US]) 18 October 1983 (1983-10-18) -----	1-31
A	US 4 650 540 A (STOLL MILTON [US]) 17 March 1987 (1987-03-17) -----	
A	US 4 454 096 A (LORENZINI ROBERT E [US] ET AL) 12 June 1984 (1984-06-12) the whole document -----	

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2005/006058

Box II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☒ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International Application No. PCT/US2005 /006058

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-13,15-17,23-31

CZ system/apparatus for melting crystalline feedstock, growing single crystal ingot using a wide diameter low aspect ratio crucible. Process using such and product obtained therefrom.

2. claims: 14,18-22

CZ system, pre-melter apparatus for growing, providing continuous flow of molten crystalline feedstock.

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 4659421	A	21-04-1987	NONE	
WO 8606109	A	23-10-1986	DK 606986 A EP 0221051 A1 FI 865130 A	16-12-1986 13-05-1987 16-12-1986
WO 03038161	A	08-05-2003	NONE	
DE 2634256	A1	02-02-1978	NONE	
US 4410494	A	18-10-1983	NONE	
US 4650540	A	17-03-1987	NONE	
US 4454096	A	12-06-1984	NONE	